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ORGANIZATIONAL MAINTENANCE: BEHAVIOR ANALYSIS AND INTERVENTION.(U)
JUN 80 J KOMAKI, R L COLLINS N00014-79-C-0011

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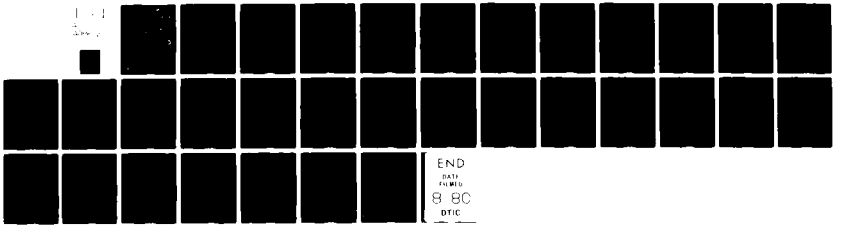

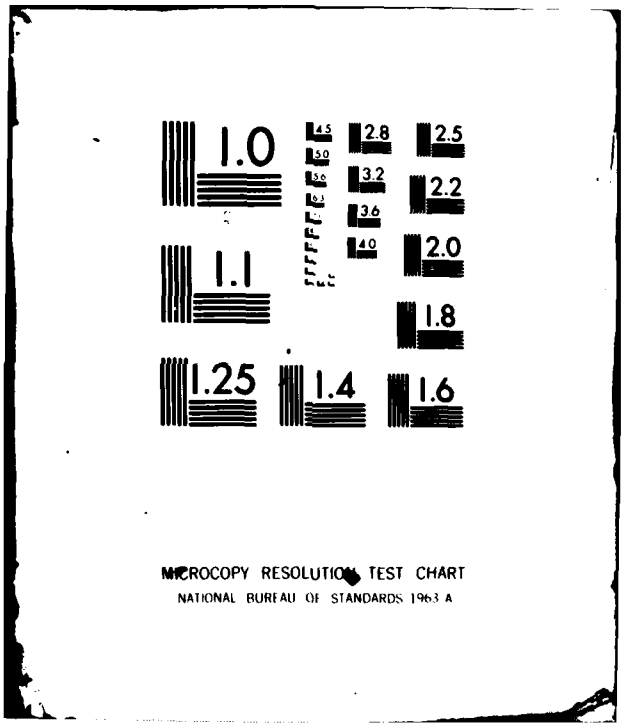
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Although the importance of preventive maintenance (PM) is widely acknowledged, ~~in both military and civilian settings,~~ there are few documented ways to improve the quality, regularity, and timeliness of maintenance. Most PM studies are not concerned with on-the-job practices; worker motivation is neglected; and there are no satisfactory measures of PM performance. One method which has been suggested as suitable for facilitating preventive maintenance is the behavior analysis approach. The potential of the approach can be seen through its documented improvements in work ser-

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tings, its successful use of performance consequences as a source of motivation, and its direct observational measurement techniques.

Based on the needs identified by Marine Corps personnel, a pilot program, based on the behavior analysis approach, was designed and implemented in a Fleet Marine Force Unit. The focus was on personnel (N=50) in the Ordnance and Motor Transport sections of a heavy artillery Battery at Camp Lejeune, ~~North Carolina~~ NC.)

First, it was determined whether the current PM system contained the components essential to effective performance. In line with the behavioral approach, the PM system was analyzed to determine whether personnel knew what to do; whether their performance was measured directly, frequently, and objectively; and whether there were consequences for their performance.

Analysis of the PM system revealed the lack of direct, frequent, and objective indicators of PM performance. As a result, a behavioral measurement system was developed which consisted of the following three performance areas: 1) Utilization of time during scheduled maintenance periods, 2) Supervision during these periods, and 3) Extent of corrective action taken. Each of the above categories was behaviorally defined and data were collected weekly by retired Marines over a 48-week period.

Analysis of the PM environment also revealed that personnel were not being motivated properly. Because there were no measures of PM performance per se and the effects of PM neglect were hidden and delayed, nothing much happened following desired or undesired performance. As a result, a motivational program was designed which included performance consequences in the form of feedback and time-off. In this program, referred to as the PM Liberty Call Program, early liberty was awarded if all PM goals had been met. Feedback was posted weekly, announcements about the early liberty were made on Mondays, and liberty was awarded on Fridays. To evaluate the effectiveness of the Program, a multiple-baseline design was used in which the Program was introduced after 15 weeks in Motor Transport and after 33 weeks in Ordnance.

The Program was not only well received, but also initially effective in the Motor Transport section with all goals being exceeded by a substantial margin. However, the final results were mixed. Performance in Motor Transport declined back to preprogram levels. No improvements were ever obtained in Ordnance.

The lackluster results of the program did not appear to be a function of the expertise, commitment, or competence of individual personnel. Instead, the PM Liberty Call Program, as it was designed and implemented, simply could not overcome the crisis management environment in which higher priority was placed on more visible, nonmaintenance commitments. Although the pilot program failed to obtain consistent improvements, several positive events developed. A better understanding now exists as to why preventive maintenance is likely to be neglected; a promising behavioral measurement system was developed which resulted in more sensitive, ongoing, and accurate information about PM performance; and feasible performance consequences were identified and well received. A refined program, based on the above findings, is currently being implemented and tested.

ORGANIZATIONAL MAINTENANCE:
BEHAVIOR ANALYSIS AND INTERVENTION
Final Report

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and
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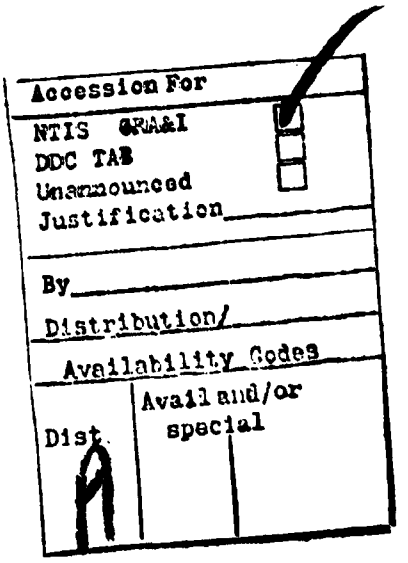


ORGANIZATIONAL MAINTENANCE:
BEHAVIOR ANALYSIS AND INTERVENTION

The benefits of preventive maintenance (PM) have been widely acknowledged in both civilian and military settings (Higgins & Morrow, 1977). In firms where downtime is expensive, preventing equipment breakdowns becomes crucial. In military settings, maintenance plays a significant role in operational readiness. Unless equipment is maintained in satisfactory operating condition, mobilization efforts will be severely impaired. Preventive maintenance also plays an important role in ensuring the safety of workers and consumers. Just how critical PM practices can be was illustrated in a recent airline crash which was purportedly caused by a failure in preventive maintenance ("Up, Up, and Away," 1979).

State of the Art

Although all readily acknowledge the importance of preventive maintenance, a review of the PM literature reveals few documented ways to insure that maintenance is done in a regular and timely fashion. Many PM reports deal with cost issues, such as the relative benefits of replacing or repairing equipment (e.g., Corder, 1976; Knight, 1977; McCarty & Moore, 1977; Wilkinson, 1968). Although this information is certainly important, it does not directly address the problem of persons in charge, i.e., how to guarantee that maintenance is, in fact, done.

Short shrift is given to worker motivation when attempts are made to improve PM practices. Typically, the emphasis is on training programs and employee scheduling systems. Numerous reports describe PM training programs (e.g., Biersner, 1975; Carpenter-Huffman & Rostker, 1976; Smith, 1961), discuss how to set up training (e.g., Hora, 1978; Johnson & Storr, 1977), or examine reference materials (e.g., Foley, 976; Post, 1975; Shriver, 1975). The focus of another large group of reports is scheduling, that is, forms are described outlining what task is being completed by which worker during what time slot (e.g., Hannon, 1977; Murphy, 1977). The assumption is that if management can train employees thoroughly enough and can structure work schedules efficiently, maintenance will be ensured (e.g, Drake, Goto, & Crooks, 1979; Schwartz, 1976). Unfortunately, recent evidence suggests that even if employees know what to do and when to do it, they may not be

motivated to perform when there are no consequences for their performance (Komaki, Heinzmann & Lawson, 1980; Komaki, Collins & Hutcheson, Note 1). In most work settings, there are few consequences for maintenance activities. When maintenance is accomplished, nothing is said or done; it is taken for granted. When maintenance is postponed, again nothing much is said or done. More importantly, the effects of maintenance neglect are not immediately apparent. Many defects may not surface until months or even years later. When it makes little immediate difference whether maintenance is done or not, it is difficult to sustain performance.

Another reason for maintenance neglect is that it is virtually impossible to determine whether maintenance is, in fact, being accomplished. Measuring PM performance is extremely difficult. There is no tangible product. Inspected vehicles look virtually the same as uninspected vehicles. Completed paperwork does not necessarily reflect the maintenance effort. Downtime, deadline rates, or costs are at best indirect measures because they reflect many factors of which PM performance is only one factor.

A review of the literature revealed that it is difficult to ensure that maintenance is done in a regular and timely fashion since most preventive maintenance studies are not directly concerned with the improvement of on-the-job practices, worker motivation is neglected, and there are no satisfactory measures of PM performance.

Potential of the Behavior Analysis Approach

The behavior analysis approach is a particularly suitable strategy for facilitating preventive maintenance for three reasons. First, the emphasis of the behavioral approach is on making meaningful improvements in actual settings. The approach has been demonstrated to be effective in a variety of work settings (refer to recent reviews by Andrasik (1979), Babb & Kopp (1978), and Prue, Frederiksen, & Bacon, 1978).

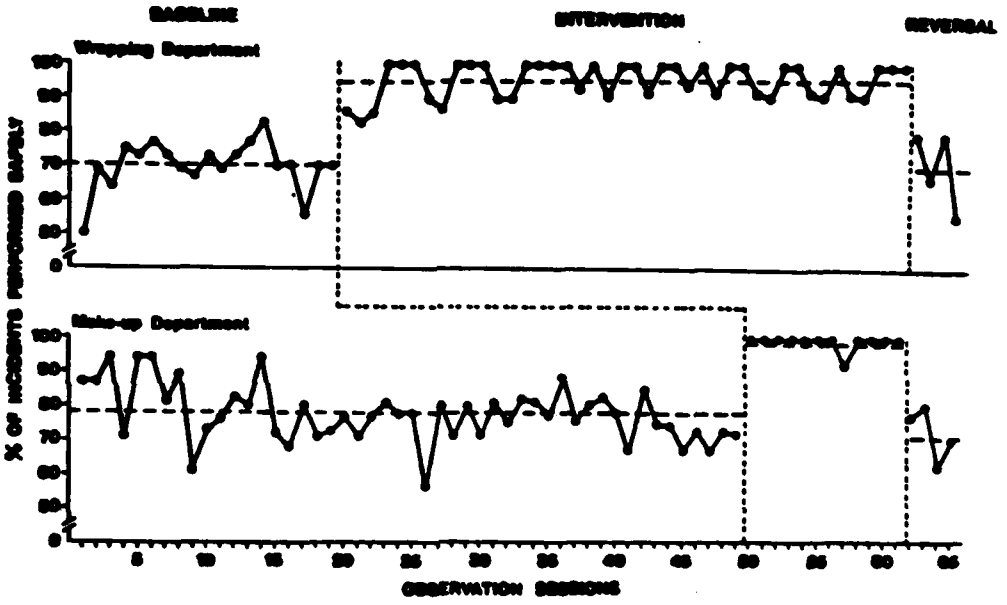
Second, the behavioral approach focuses on the consequences of performance as a source of motivation. Consequences ranging from nonmonetary reinforcers, such as feedback, to activity reinforcers, such as time-off, have been arranged following desired performance. The principal investigator and her associates, for instance, successfully used the behavioral approach to improve safety in two industrial sites in the private and pub-

lic sectors (Komaki, Barwick, & Scott, 1978; Komaki, Heinzmann, & Lawson, 1980). Following the specification and communication of desired performance, employees were reinforced in the form of feedback indicating their level of desired behaviors several times a week. The results were successful in both increasing safe practices on the job (Figure 1) and reducing accidents.

Figure 1

Results of a Behavioral Safety Program

Introduced in Two Food Manufacturing Departments



Note: From "A behavioral approach to occupational safety: Pinpointing and reinforcing safe performance in a food manufacturing plant" by J. Komaki, K. D. Barwick, and L.R. Scott, Journal of Applied Psychology, 1978, 63,434-445. Copyright 1978 by American Psychological Association. Reprinted by permission.

Third, the behavioral approach includes measurement techniques which make it possible to analyze areas that traditionally have not been investigated in depth (Komaki, Collins, & Thoene, 1980). The principal investigator and her associates have designed measurement systems to reflect such elusive

and uncharted areas as customer service in a retail merchandising firm (Komaki, Collins, & Temlock, Note 2) and the quality of care in hospital emergency rooms (described in Komaki, Collins, & Thoene, 1980). These measurement systems were direct and frequent, i.e., performance was assessed on the job by trained observers at least once a week. They were objective, i.e., desired practices were defined and redefined until two persons, recording independently, agreed with one another a substantial amount (80-100%) of the time. These behavioral measurement systems not only helped clarify desired practices but also provided direct, objective information about the level of service, two prerequisites to improving and maintaining performance. For a further description of behavioral measures and the steps involved in developing the present measurement system, please refer to Komaki, Collins, and Thoene (1980).

Although there had been no demonstrations of the effectiveness of the behavioral approach in improving preventive maintenance practices per se, the potential of the approach could be seen through its documented improvements in work settings, its successful use of performance consequences as a source of motivation, and its direct observational measurement techniques.

Arrangements for Pilot Program

Preventive maintenance had been identified as a recurring problem in the Marine Corps, particularly with the lowest level (1st echelon) personnel who do not engage in maintenance fulltime. Arrangements were made to conduct a pilot program, which would be based on the behavior analysis approach and designed to improve organizational (preventive) maintenance in a Fleet Marine Force unit at Camp Lejeune, North Carolina. The focus was on the performance of approximately 50 Marines in the Ordnance and Motor Transport sections of a heavy artillery Battery. The primary equipment in Ordnance consisted of six eight inch self-propelled Howitzers (M110). Equipment in Motor Transport included four jeeps, three radio jeeps, and nine five-ton trucks. The Battery was one of three in a Battalion. Battalion personnel report to Regimental personnel, who, in turn, report to Division personnel.

The Challenge

The first challenge was to design a system that would work well within the existing system. At the outset, it was assumed that the work environment would not change dramatically. In analyzing the ongoing PM system in the Marine Corps, it was found (1) that equipment was supposed to be inspected once a week by 1st echelon personnel; (2) that Weekly PM Checklists, noting items to be inspected, were available; (3) that time was supposed to be set aside each week and these times were scheduled in advance and noted on a Weekly Training Schedule; and (4) that identified discrepancies were supposed to be corrected by 1st echelon personnel or that further action, i.e., parts ordered or the vehicle sent to the next echelon for repair, was supposed to be initiated on Equipment Repair Orders. These procedures for inspecting, detecting, and repairing discrepancies seemed to be both well thought out and firmly established, thus the procedures were taken as given. Likewise, it was assumed that reducing the turbulent nature of the work environment with its many nonmaintenance commitments, significantly upgrading the workforce, or altering the design, age, or use of the equipment would be impossible.

The second challenge concerned the area of preventive maintenance itself. Since PM efforts are virtually invisible, and its effects are delayed, it is difficult to measure it accurately. Besides, preventive maintenance is relentness, i.e., it must be done regularly. The challenge was to design a system for an area, with few immediate or dramatic effects, that needs to be done week in and week out.

Procedures

The current PM system was first analyzed to see whether it contained the components essential to effective performance. In line with the behavioral approach, it was determined whether personnel knew what to do; whether their performance was measured directly, frequently, and objectively; and whether there were consequences for their performance. Based on this initial analysis of the system, a measurement instrument and a motivational program were then designed.

Clarity of Performance

Analysis: Questions were raised about whether 1st echelon personnel knew what to do, a prerequisite to performance:

* Are desired practices clear?
* Is training adequate?

Many persons expressed concern about the technical expertise of maintenance personnel. Personnel generally noted either the minimal number of persons with technical training, the fact that training was not available for the maintenance of track vehicles, and the deficiencies in the PM manuals.

Knowledge Appraisal: As a result, a decision was made to assess the technical knowledge level of maintenance personnel. Two types of questions were devised to assess their knowledge:

1. Identification, e.g., Can you identify the fill plug on the steering gear box?
2. Activity, e.g., What do you do when checking the oil level in the engine compartment? What do you look for?

Three individuals from Motor Transport and three from Ordnance were selected randomly each week. Each was asked three Identification and three Activity questions. The percentage of questions answered correctly was calculated for each section.

The content area of the questions was limited to top-ranking items on the Weekly PM Checklists. The Weekly PM Checklists in Motor Transport and Ordnance contained 64 and 41 items, respectively, ranging from brake fluid levels to the conditions of seats. To ensure that items judged to be more important were emphasized, items were assigned priorities. On-site personnel rated the importance of all items on the Weekly PM Checklists, using a seven-point scale. Each item was then rank ordered. The questions devised included the top-ranking 25 items on the Weekly PM Checklists. In the Motor Transport section, for instance, select items were rank ordered as follows:

1. Brake fluid
10. Steering gear assembly
20. Starter/accelerator
30. Instrument panel
40. Air cleaner/breather cap
50. Cargo bed/dropsides
60. Seats

The information obtained during the knowledge appraisal was used to assess whether personnel were technically qualified to conduct weekly PM checks.

Measurement of Performance

Analysis: Next, it was determined what information was currently used by on-site personnel to judge maintenance performance. The following questions were then raised:

* Do the indicators reflect performance directly?
* Is the information collected at least monthly?
* Is the information objective?

In an area such as preventive maintenance, it is important that the measure be: (1) direct, so that it assesses personnel performance; (2) frequent, so that it captures what personnel are doing on an ongoing basis; and (3) objective, so that it reflects how well personnel are actually doing.

Three primary indicators were noted. One frequently mentioned indicator was the deadline rate, i.e., the percentage of inoperative combat essential equipment. Unit personnel continuously feed information about inoperative or unsafe equipment into the management information system. This information is then summarized from all units, and subsequently used to calculate the readiness rating. The readiness rating is distributed weekly to the Commandant of the Marine Corps and other intermediate levels of management; an extract of this information is presented on a monthly basis to the Joint Chiefs of Staff. When the readiness level takes a downward trend, efforts are immediately begun to rectify the situation. Rectification generally consists of one of two functions: ordering authorized vehicles, a supply function, or repairing inoperative vehicles, a maintenance function.

The deadline rate was found to be lacking as a measure of PM performance, primarily because it does not directly reflect performance. Instead, it reflects vehicle condition. While preventive maintenance practices do affect vehicle condition, so do other factors---age, use, and design of the vehicles; supply system; and the availability of funds and personnel. More importantly, evidence of maintenance neglect often does not surface in vehicle condition for months and even years. As a result, it is not possible to determine current PM practices by relying solely on information about present vehicle condition. Since the deadline rate is not only weighted heavily by factors other than PM practices, but also because it does not

necessarily reflect current PM practices, the deadline rate is not a sensitive measure of a unit's ongoing PM performance.

A second index is the yearly evaluation of a unit's field supply and maintenance efficiency (FSMAO). During this evaluation an analysis team spends a week on site talking with Battery and Battalion personnel and sifting through records. This analysis is done to determine whether the unit is complying with Marine Corps directives and publications. After the analysis, the team writes a report which outlines all deficiencies. The FSMAO report is forwarded to both higher level personnel (Regimental and Division), who use it to evaluate the performance of unit personnel, and to unit personnel, who are expected to immediately correct all discrepancies.

The FSMAO report, although it more directly reflects the performance of a given unit, is not sufficient as an ongoing measure of performance because it is done only annually. One problem with an annual, preannounced evaluation is that it is time specific and may not accurately reflect how personnel perform the rest of the year. A second problem with an annual assessment is that it emphasizes, by necessity, those aspects with tangible products, e.g., submitted tool kit requisitions, established pre-expended bins, properly prepared equipment records. Unfortunately, finding the paperwork, tools, and repair parts in proper order does not mean that maintenance was accomplished during the previous year. Personnel could complete what are euphemistically referred to as paper PMs without ever touching a vehicle.

The third indicator is the Limited Technical Inspection, generally referred to as LTI. LTIs are done to determine the extent and level of maintenance required to restore the equipment to a specified condition. Standard forms are used. LTIs are always done prior to equipment being dispatched. On occasion, they are done when there are indications that maintenance is being neglected. When "excessive" discrepancies are found, the discrepancies are brought to the attention of higher level personnel who, in turn, notify unit personnel, who are expected to rectify the situation.

The LTIs were also found to be lacking as a measure of PM performance. Like the deadline rate, they reflect vehicle condition, which is weighted heavily by factors other than current PM practices. Questions were also raised about the accuracy of the information being obtained during the LTIs. Items on the standard LTI form are often so briefly and vaguely stated (e.g., engine) that it becomes difficult for even well trained

personnel to agree as to whether an item should be checked satisfactory or unsatisfactory (i.e., needs repair, adjustment, or replacement). During the course of the pilot program, evidence was collected regarding interrater agreement. Out of the 82 LTIs, interrater reliability was assessed 6 and 3 times in Motor Transport and Ordnance, respectively. During the interrater reliability checks, two trained personnel independently inspected a randomly selected vehicle within a 24-hour period. Afterwards, items marked as unsatisfactory were examined. An agreement was defined as any item designated unsatisfactory by one rater which was also noted unsatisfactory by the other rater. Interrater reliability was calculated as the number of agreements divided by the number of agreements plus disagreements. The results showed that the two raters were in agreement only 71% and 51% of the time in Motor Transport and Ordnance, respectively. On over one quarter to one half of the items they disagreed as to whether the item was unsatisfactory. These findings indicate that there are questions about the LTI, as it is currently being conducted, as an accurate source of information regarding vehicle condition.

Measurement System: Because of the problems noted above with the three on-site indicators, an observational measurement system was designed that was direct, frequent, and objective. Information about PM performance was collected by retired Marines who went on-site and recorded weekly in both the Motor Transport and Ordnance sections. Data sheets and observational codes, containing definitions and observational procedures, were fieldtested and refined until two independent monitors could agree a substantial portion of the time (90-100%) about the occurrence of different PM practices.

The following three performance areas were monitored:

1. Time utilization was defined as the number of personnel engaged in PM activities during scheduled PM periods.

A monitor went to the gun park or motor transport section and recorded the number of individuals present and the number of individuals on-task in each section. "Present" was defined as being "within 1 meter of a vehicle (including extension of a vehicle or disassembled part) and stationary for 5 seconds." "On-task" was defined as "manipulating equipment, vehicle, or disassembled part with hands or tools for any

length of time." A monitor observed five times (approximately once each hour) during the scheduled PM period, as noted on the Weekly Training Schedule, for a given day. So as not to establish a predictable pattern, the six guns in Ordnance and the three types of vehicles in Motor Transport were observed in a different random order during each observation. In Motor Transport, time utilization was calculated as the mean number of persons on-task (the total number of persons on-task divided by the number of observations (usually 5). In Ordnance, time utilization was computed as the mean number of persons on-task per gun (the mean number of persons on-task was calculated for each gun, then these means were summed and divided by the number of guns).

2. Supervision was defined as the percentage of time a supervisor was present when personnel were on duty during scheduled PM periods.

During each observation (described above), the monitor also recorded whether a supervisor (Battery Motor Transport Officer, section chief of gun) or higher ranking officer (e.g., Battery Commanding Officer) were present. "Present," in this case, was defined as being within 10 meters of the vehicle or gun being worked on; interior areas (e.g., Motor Transport hut) were excluded. In Motor Transport, supervision was calculated as the number of times a supervisor or higher ranking officer was present divided by the total number of observations during which at least one other person was present, yielding the percentage of supervision. In Ordnance, supervision was computed as the percentage of supervision per gun (the percentage of supervision was calculated for each gun, then these percentages were summed and divided by the number of guns with at least one other person present).

3. Action taken was the extent to which items identified as needing attention were either corrected, or the paperwork was initiated, so as to order parts or to enable further repairs.

A total of 18 items, all identified as needing repair on the Weekly PM Checklists, were selected for further analysis in each section. Three items were selected from each of the six guns in Ordnance and from six vehicles selected randomly in Motor Transport. To insure that the more important items would be examined, items with the highest priority ranking were selected. For each item selected, a determination was made

as to whether either of two appropriate remedial actions were taken. First, it was determined whether the item had been corrected by examining the vehicle itself. If the item had not been corrected, the monitor determined if the appropriate paperwork had been initiated that would result in either forwarding the vehicle to a higher echelon repair shop or ordering the parts necessary for repair. Action Taken was computed as the percentage of items in which follow through was taken for each vehicle or gun divided by the total number of vehicles or guns.

Interrater Reliability: Interrater reliability was assessed frequently, that is, on the average of one out of every two times data were collected. Two monitors independently observed and recorded. At the end of the data collection period, their recordings were compared to see whether or not they agreed. With Time Utilization, reliability was calculated by comparing one monitor's counts of persons on-task with the other monitor's and then dividing the smaller number by the larger number and multiplying by 100 for a percentage figure.

With Supervision and Action Taken, reliability was computed using the percentage agreement method as follows:

$$\text{Reliability \%} = \frac{\text{\# of agreements}}{\text{\# of agreements \& disagreements}} \times 100$$

With Supervision, an agreement was scored when one monitor noted that a supervisor was present and at least one other person was present during a given observation and the other monitor also recorded the same. For Action Taken, those items that had been marked as having no action taken were compared on an item-by-item basis.. An agreement was scored when any item designated as "no action" by one monitor was also noted by the other monitor.

In contrast to the interrater agreement of the LTIs, the above reliability figures were extremely high, ranging between 90% and 100%, indicating the objectivity of the observational codes and the accuracy of the information being obtained:

	Motor Transport	Ordnance
1. Time Utilization	99%	100%
2. Supervision	99%	98%
3. Action Taken	100%	97%

Consequences of Performance

Analysis: The next and last step was an analysis of the work environment itself. To determine how and if personnel were being motivated to perform properly, the following questions were asked:

* Are there any consequences for performance?
* Are these consequences related to performance?
* Are organizational incentives related to performance?
* Is there a balance of consequences for desired and undesired performance?

Attention was directed to the consequences of performance, that is, those events that occur to the individual following his or her performance. Examples of consequences include the actions of superiors, peers, and subordinates, as well as organizational incentives such as promotions and salary increases. In work setting after work setting, dramatic improvements occur when consequences are frequent and related to both desired and undesired performance. When it makes little difference whether one behaves in a desired or undesired manner, it is difficult to motivate personnel to improve and maintain their performance.

The analysis of the PM environment revealed that personnel were not being motivated properly. There were few favorable consequences for desired performance. Because there were no measures of PM performance per se, preventive maintenance was automatically low priority. Preventive maintenance received less attention because no one, at any level, had any accurate, ongoing information about PM activites. When it is difficult to judge how well personnel are performing, consequences are rarely provided. That was definitely the case with the area of preventive maintenance:

Desired Performance	Consequences
Correctly identify discrepancies.	Little recognition.
	No follow through.

Because of the difficulties in measuring PM performance, there was little recognition of quality performance on a day-to-day basis. It was difficult to tell when, how, and if the job had been completed. Consequently, it was rarely noted in formal appraisals. Even a natural consequence, that of keeping the equipment running, was frequently aborted. When 1st echelon

personnel correctly identified discrepancies during weekly PM checks, follow through action was rarely completed promptly. Minor repairs and adjustments were not made, parts were not ordered, vehicles were not sent for repair. Only when the vehicle finally broke down were these taken care of. When there are so few consequences for performing as desired, it is difficult to maintain performance for extended periods of time in this environment.

On the other hand, when preventive maintenance was not completed, there were also few consequences:

Undesired Performance	Consequences
Procrastinate doing weekly PM.	Nothing happens.
Postpone follow through.	Vehicles continue to operate

Again, it was difficult to determine when PM had not been done, so little corrective action was taken. Uninspected vehicles not only do not look any different than inspected ones but evidence of maintenance neglect often does not surface for months and even years. There was little said or done when the vehicles continued to operate. As long as there are no consequences for neglecting maintenance, PM activities will continue to be relegated to a lower status.

The only time personnel heard about the area of preventive maintenance was when a major mishap occurred (e.g., one quarter of a unit's trucks were deadlined because of transmission problems). Then repercussions would reverberate up and down the line. Such an approach is generally referred to as management by exception. There are at least two problems with this approach in which persons only hear when problems surface. One, this approach lends itself to crisis management. When a crisis, such as the one above occurs, attention is focused on preventive maintenance. However, when another crisis occurs, attention shifts to the other area and then maintenance is forgotten in the shuffle of more measurable commitments. The second problem is that management by exception focuses by its very nature on exceptional events that do not necessarily reflect performance. In the case of equipment failure, it is often difficult to trace whether breakdowns were caused by equipment design or maintenance neglect. Even if maintenance were the reason, the neglect may have occurred long before the present personnel arrived. Needless blame at any level is counterproductive to motivation. In summary, it

was concluded that the PM environment with its lack of contingent consequences for desired and undesired performance was not conducive to motivating personnel.

Based on the above analysis, it was recommended that more frequent consequences should be arranged for desired performance and that performance feedback should be provided. This was to be done to ensure that personnel can recognize quality performance and rectify unsatisfactory performance.

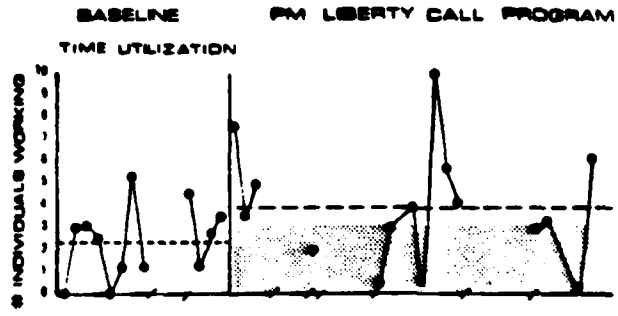
Performance Consequences: Various potentially reinforcing events were discussed. One such event was feedback which had been demonstrated to be an effective improvement strategy in many work settings. While feedback has the advantage of ready acceptability and low cost, there was some question as to its effectiveness when used alone. Of particular concern was the less than dramatic area of maintenance and the many nonmaintenance commitments of the setting. So, it was decided to combine feedback with at least one other performance consequence.

Monetary incentives were ruled out, as they were not feasible in this setting. Likewise, token economy systems, making use of points and privileges, were also ruled out because of their extensive recordkeeping requirements. Time off, on the other hand, was highly recommended. Time off had been identified as a highly desired incentive by Army personnel (Datel, 1972) and it was currently being used at Camp Lejeune as an incentive in an attempt to reduce the number of unauthorized absences. However, many personnel questioned the effectiveness of time out in this situation. Because maintenance needs to be performed regularly and consequences should be timely, it was important that the consequences be provided fairly frequently. The amount of time assumed by on-site personnel to have any incentive value (4 to 8 hours), however, was viewed as a prohibitive amount of time in any work week. Alternatives were considered. One possibility was to drop the idea of time off altogether; another was to provide a greater amount of time off less frequently; another was to enhance its incentive value and provide a smaller amount more frequently. Eventually, it was decided to try the latter. Although only 30 to 60 minutes could be alloted on a weekly basis, its availability was announced in advance and the time-off was scheduled for Fridays. Based on all the above information, a program providing consequences for both desired and undesired performance was designed to improve PM performance.

PM Liberty Call Program

The program, referred to as the PM Liberty Call Program, made early liberty contingent on performance in the areas of time utilization, supervision, and action taken. If all PM goals were met for the week, then an early liberty call was established for the entire Battery. Announcements about the early liberty were made no later than the Monday morning assembly, and early liberty was scheduled for Friday. Feedback was also provided each week in the form of a graph which was posted at Battery Headquarters. Figure 2, for example, shows a sample graph which illustrates what personnel in the Motor Transport section received as feedback after the introduction of the PM Liberty Call Program.

Figure 2
Feedback Graph of Time Utilization
for Motor Transport

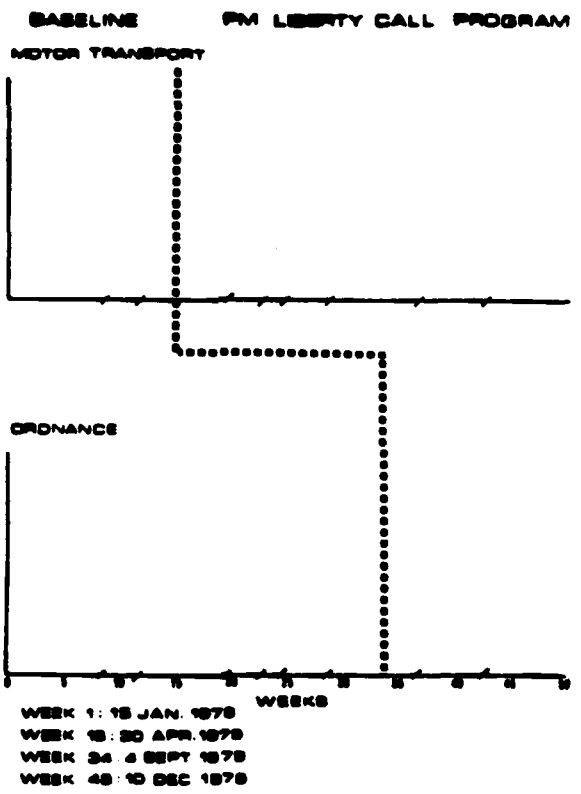


The PM goals were determined by on-site personnel in conjunction with project staff and in reference to previous performance levels. The goals set for each of the measures are shown below:

	Sections			
	Motor Transport		Ordnance	
Performance Areas	Intermediate Goal	Ultimate Goal	Intermediate Goal	Ultimate Goal
Time Utilization	3	4.5	3.5	4.5
Supervision	50%	67%	67%	75%
Action Taken	67%	75%	75%	85%

To evaluate the effectiveness of the PM Liberty Call Program, information was collected weekly over a 48-week period, beginning the week of 15 January 1979 and continuing through the week of 10 December 1979 (Figure 3). Information was collected in the two sections prior to the introduction

Figure 3
Diagram of Multiple-Baseline Design
Used to Evaluate Effectivness of Program



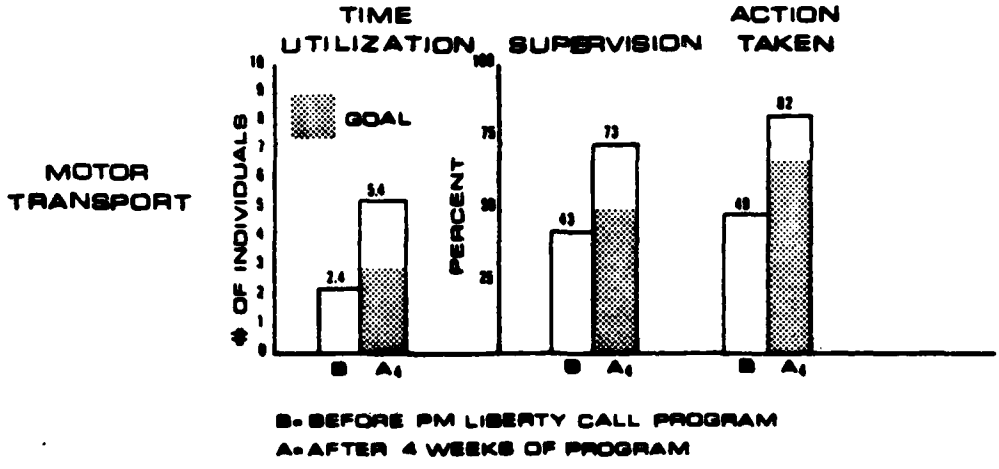
of the program, referred to as the baseline period After 16 weeks the PM Liberty Call Program was introduced in the Motor Transport section the week of 30 April. After 34 weeks, the program was introduced in the Ordnance section the week of 4 September. Information continued to be collected to determine whether performance improved after, and not before, the staggered introductions of the program in the two sections.

Results

PM Performance

The effects of the PM Liberty Call Program were mixed. Initially, the Program in the Motor Transport section was quite effective as can be seen in Figure 4. Motor Transport personnel exceeded by wide margins all PM goals

Figure 4
Results in Motor Transport
Before and After Four Weeks of the Program



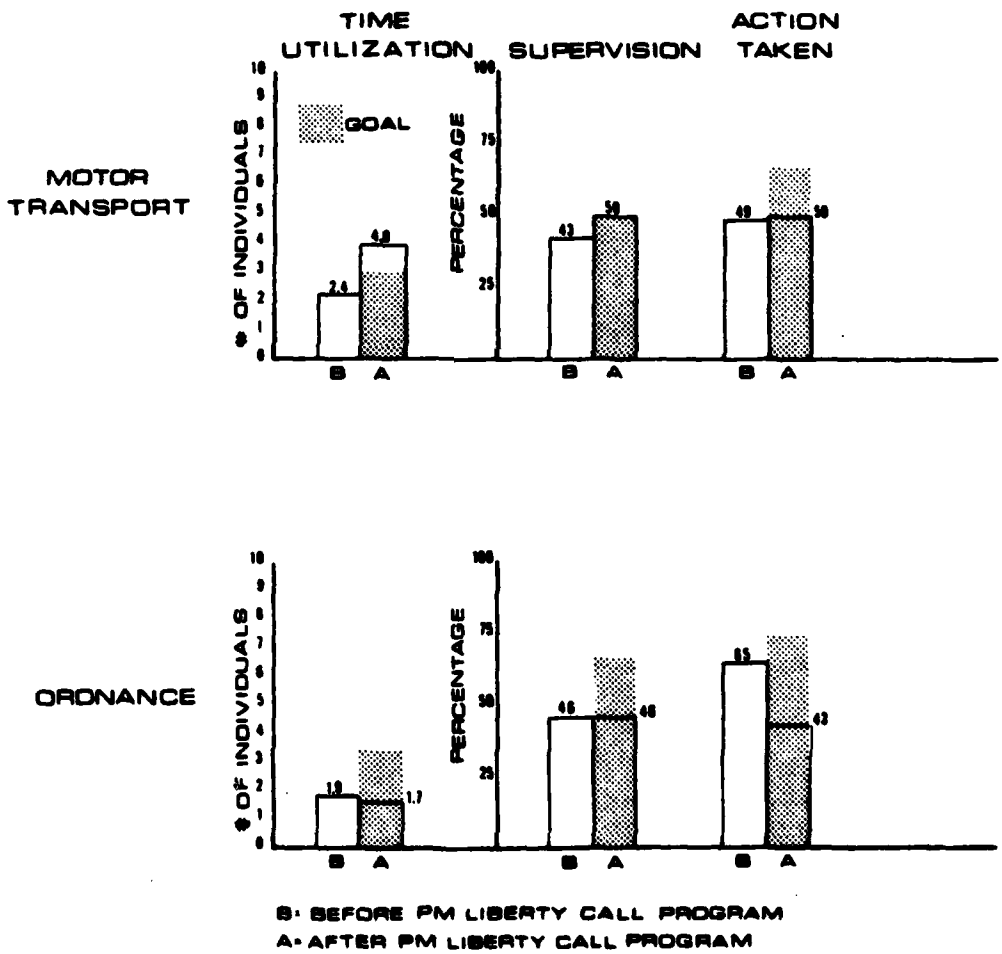
(indicated by shading) during the first four weeks. Time Utilization doubled from an average of 2.4 Marines working during scheduled maintenance times to an average of 5.4 Marines, substantially exceeding the goal of 3.0. Likewise, the percentage of time a supervisor was present almost doubled from an average of 43% to 73%. Action taken on discrepancies also improved from an average of 49% to 82% of the items needing attention, well exceeding the goal of 67%. During this time, PM goals were met three out of the four weeks and early liberty was awarded.

After the first month, however, performance in the Motor Transport section declined. By the end of the year performance had fallen to such an extent that the goal was exceeded only slightly for Time Utilization and just barely attained for Supervision (Figure 5). Action Taken was affected

the most, with personnel not even attaining the goal and performing no better overall after the program (M=50%) than before the program (M=49%).

In Ordnance, the PM Liberty Call Program did not result in any improvements whatsoever as can be seen in Figure 5. For Time Utilization and Supervision, performance remained virtually the same. For Action Taken, performance actually declined over the course of the program.

Figure 5
Results in Motor Transport and Ordnance
Before and After the Program



Performance varied considerably from week to week as shown in Figures 6 and 7. The week-to-week changes were particularly striking in Motor Transport. During weeks 33, 34, and 35, for instance, Action Taken went from 0% to 89% and back to 0% in the space of three weeks time. The precipitating events for fluctuations such as this were not clearly related to any particular nonmaintenance commitments nor were they consistent from one section to another.

Personnel Reactions

First echelon personnel had a positive but qualified reaction to the PM Liberty Call Program. In interviews with project staff, it was noted that they particularly liked the fact that it "gave them something to work for" and it "gets more people down here." One Marine specifically mentioned that he liked "people observing consistently." The main problems mentioned were the frequent conflicts in scheduling and the limited amount of early liberty actually awarded (10 to 15 minutes rather than the 30 to 60 planned).

Supervisory Support

Initially, most persons in charge readily acknowledged the importance of preventive maintenance. However, no one seemed particularly displeased with the quality of maintenance being accomplished, given the time and resources available. When asked to estimate the extent of time being spent and action taken, for instance, their estimates were frequently higher than warranted from the information being collected by the monitors.

In designing the Program, persons in charge discussed Program arrangements at length with the project staff. At the beginning of each phase, both the Battalion and Battery Commanding Officers personally participated in an assembly of the entire Battery during which the Program was announced and described. Immediately after the introduction of the Program in Motor Transport, personnel were reminded of PM goals and were told about their progress at formations. When Motor Transport attained all goals, arrangements were made for early liberty for the entire Battery. After a while, however, nothing much was said about the Program. When asked what had been said at formation, one Marine noted that in the beginning statements about the Program were frequent. However, in regard to the present status of comments at formation he succinctly noted, "nothing lately."

Figure 6

Week to Week Results in Motor Transport

Before and After the Program

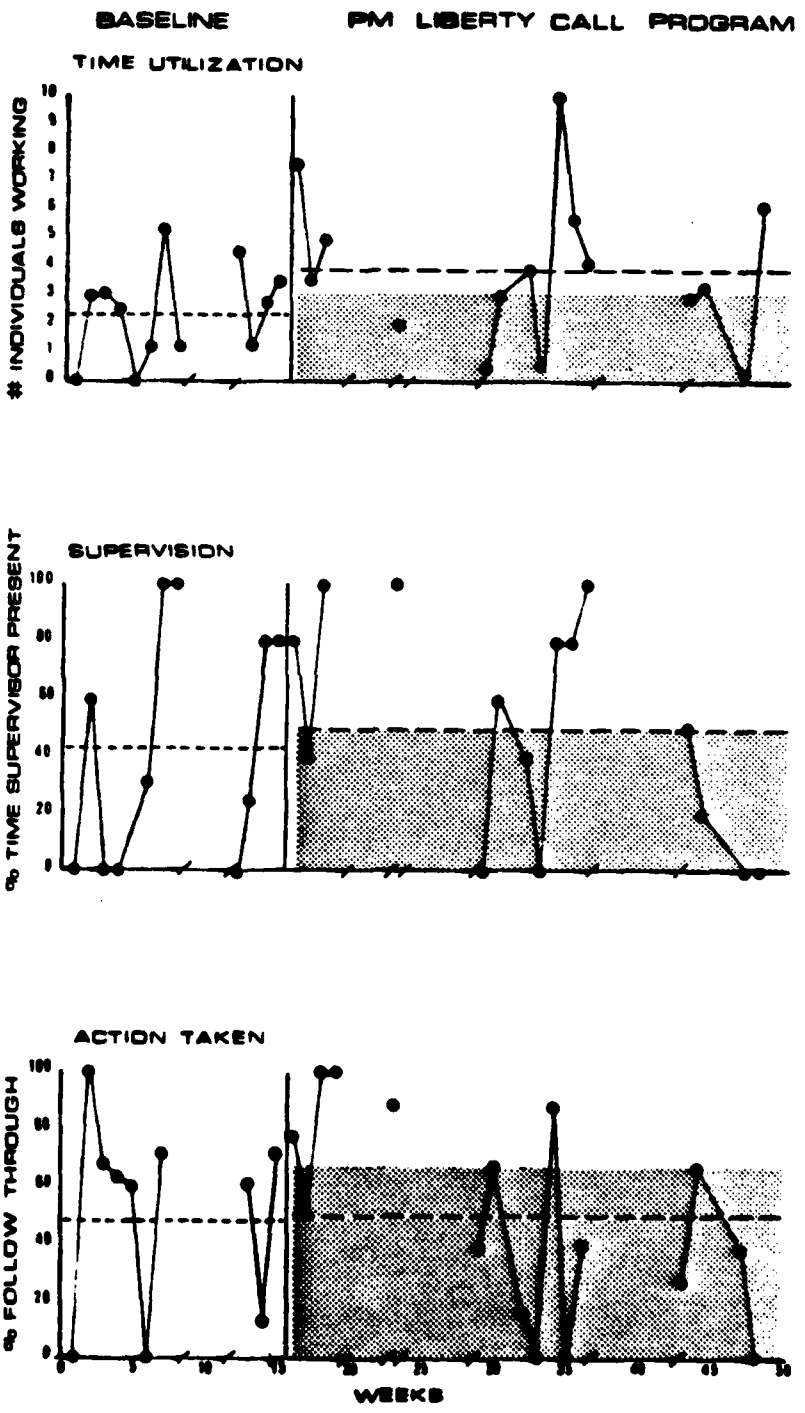
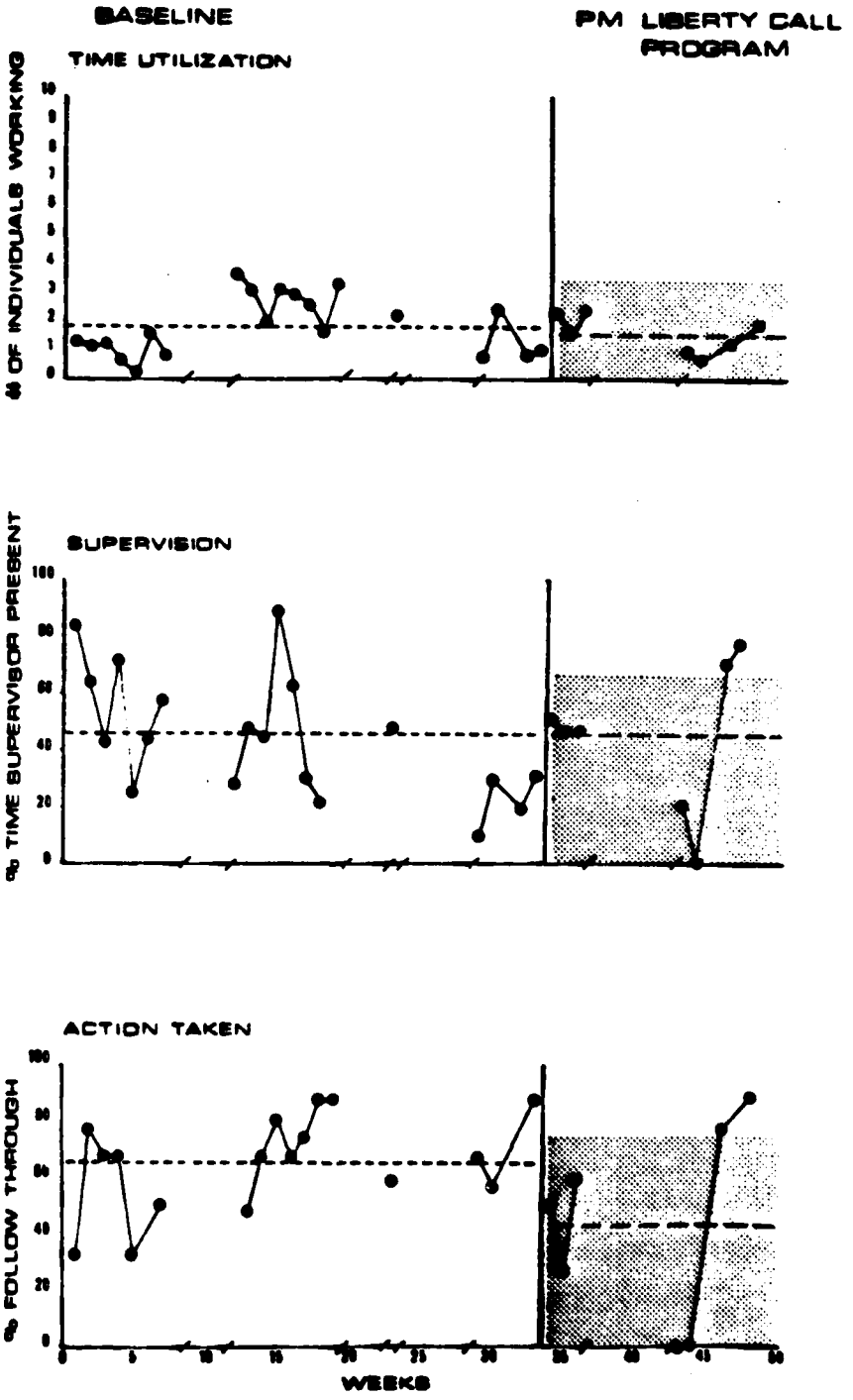


Figure 7

Week to Week Results in Ordnance

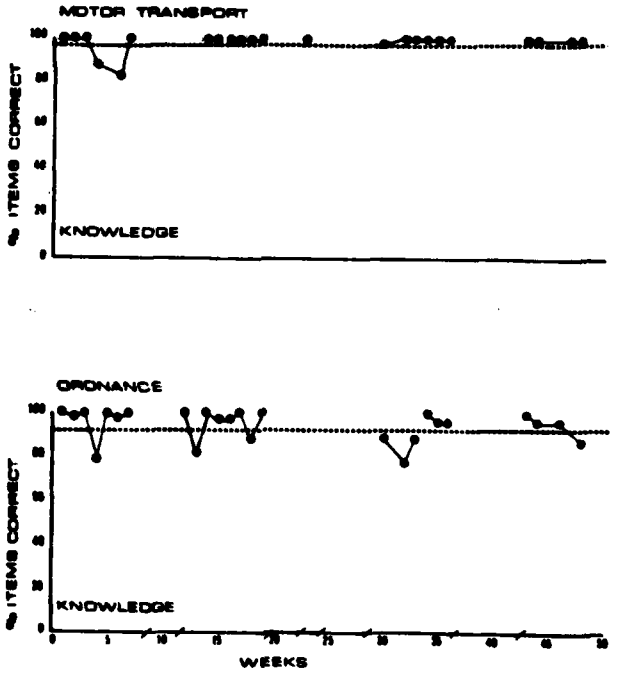
Before and After the Program



Discussion

Many factors were, no doubt, responsible for the lackluster results of the PM Liberty Call Program. One frequently mentioned factor which was not responsible, however, was the knowledge level of personnel. Persons in both Motor Transport and Ordnance demonstrated from week to week as shown in Figure 8 that they knew what to do when conducting a weekly PM check.

Figure 8
Knowledge Level of Motor Transport
and Ordnance Personnel



The average percentage of questions answered correctly was 99% and 94% in Motor Transport and Ordnance, respectively. As a result, it was concluded that maintenance was not below par because of a lack of technical expertise on the part of 1st echelon personnel.

Shortage of personnel was sometimes suggested as a reason for maintenance neglect. The implicit assumption is that if only the authorized number were on board, then PM performance would be up to par. Unfortunately, this was not the case. During the first part of the year when PM performance was judged to be below standard, the total strength of the

Figure 9

Total Strength of Battery

Throughout Year

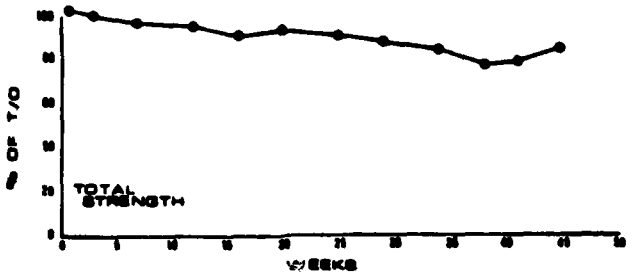


Figure 10

Total Strength of Selected Positions

in Motor Transport Throughout Year

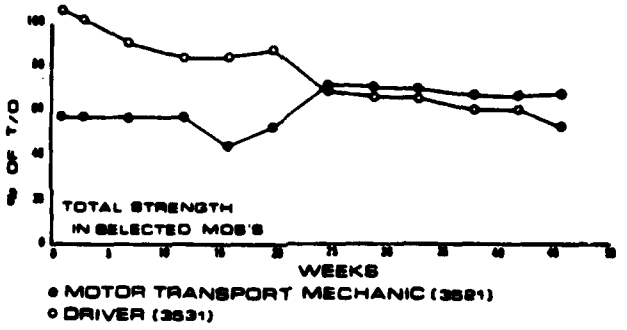
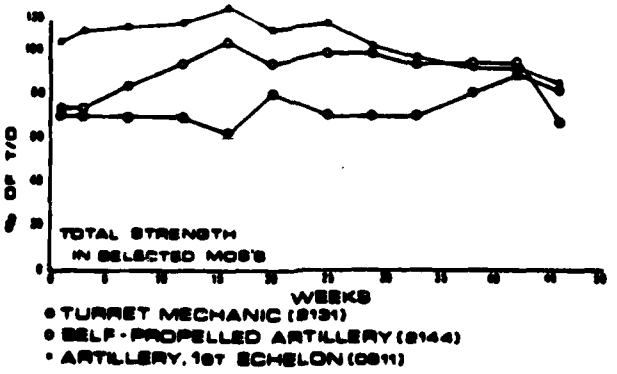


Figure 11

Total Strength of Selected Positions

in Ordnance Throughout Year



Battery (Figure 9) and selected positions in Motor Transport (Figure 10) and Ordnance (Figure 11) were over 100%. So the presence of an authorized number of personnel per se is not sufficient to insure that the maintenance will get done.

A third factor that is sometimes mentioned regards the individuals in charge. The implication is that if these individuals were more committed or more competent, then maintenance would not be a problem. It should be noted that the unit chosen was judged to be representative. Although the evidence presented thus far does not put this particular unit in the most favorable light, there is no evidence to suggest that it was any different from any other unit or that the individuals in charge were any less committed or competent. During the course of the project, there was the usual turnover with changes in the Commanding Officers of the Battalion and Battery as well as the maintenance officer (S-4) and various lower level supervisory personnel. The presence or absence of any one individual was not responsible for the less than dramatic changes.

For the area of preventive maintenance as it is currently being handled in the Marine Corps, individuals are not the problem, the crisis management environment is. The way in which priorities are arranged makes it very difficult to conduct maintenance properly. In the press of more measurable commitments, higher level personnel indirectly encourage unit personnel to neglect maintenance. No individual, no matter how committed, could unearth maintenance from its lower priority status. Even if unit personnel wished to show how additional commitments impair maintenance, they have no way of documenting its deleterious effects. Because there are no measures of PM performance per se and the evidence of maintenance neglect is hidden and often delayed, maintenance inevitably takes a back seat to more visible commitments.

To illustrate: All personnel readily acknowledged the importance of maintenance. One Marine simply noted that "if the trucks are not up, you can't go anywhere." However, the actual priority given to maintenance was very different. When asked what priority is placed on PM compared to other areas, personnel in Motor Transport (MT) and Ordnance (Ord) rated it as follows:

high	1	2	3	4	5	6	7	low
			Ord		MT			

One Marine succinctly noted that he would rate PM a "2 on the training schedule but because of the many other commitments he would actually rate it a 6." First echelon personnel noted that there seemed to be more emphasis on other activities such as close order drill, field days, flu shots, dental appointments, and classes.

When maintenance was scheduled, it was scheduled for a sizeable portion of the work week (15 hours on the average). However, weeks would go by, during which no maintenance was scheduled. For a total of 16 weeks (9-11, 20-22, 24-28, 37-42), the Battery was primarily engaged in field firing exercises or preparing for a major inspection so maintenance was not even scheduled. Even during the weeks that maintenance was scheduled, maintenance activities were deleted during at least 8 weeks and other activities were added on at least one day. The net result was that the maintenance schedule was left intact for only one half of the weeks (23 out of 48) during the year. Even if persons in charge could make maintenance their first priority, they have limited control over maintenance scheduling which is related in part to the fact that they have no immediate evidence to show the deleterious effects of maintenance neglect.

Another illustration: From one third to one half of unit personnel were found to be unavailable to do maintenance on any given day. On two fairly "typical" days in December 1979, for example, 40 persons out of a total of 89 in the Battery either were on the rifle range, attending classes (cannoneer, driver, basic skills), assigned to guard duty (mess, regimental, light), a member of a working party, in the brig, or on leave. The above assignments are made first. If maintenance is scheduled for that day, the burden falls on whomever remains. Rarely if ever are personnel first specially selected for maintenance and then assignments made for working parties and so forth. Again, in the press of more measureable commitments, maintenance is typically relegated to a lower status.

In summary, it did not appear that the lackluster results of the PM Liberty Call Program were a function of the lack of qualified, committed, or competent personnel. Instead, the PM Liberty Call Program, as it was conceived and implemented, simply could not overcome the priority placed on more measureable, nonmaintenance commitments.

Although the pilot program failed to obtain more consistent improvements in the performance of maintenance, there were several promising developments:

1. As a result of the analysis of the work environment, a better understanding now exists of why preventive maintenance is likely to be neglected.
2. A behavioral measurement system was developed which resulted in more sensitive, ongoing, and accurate information about maintenance performance.
3. A motivational program incorporating feasible performance consequences was developed and found to be well received.

Next Step

As a result of these initial findings, a refined program is currently being implemented and tested in another heavy artillery Battery at Camp Lejeune. To bolster the priority level of maintenance relative to more visible commitments, information about the unit's PM performance will be extracted on a monthly basis and provided to key individuals in the chain of command (Regiment, Division). So that individuals in charge at the unit level can more actively support the program, a list of checkpoints and diagnostic aids will be constructed and unit personnel will be encouraged to examine each throughout the week. Because the measurement system was judged to be particularly important in reflecting ongoing PM performance, it will be retained. The Time Utilization and Supervision measures, which are dependent on the Weekly Training Schedule, will be replaced by a measure which does not consider <u>when</u> the work got done during the week but only assesses <u>whether</u> the work got done within the week. The performance consequence of feedback will also be retained; however, efforts will be made to enhance its effectiveness. By making these revisions, it is hoped that there will be substantial and sustained improvements in preventive maintenance and that this revised program will serve as a demonstration for other units within the Marine Corps.

Reference Notes and References

Reference Notes

1. Komaki, J., Collins, R., L. & Hutcheson, P.P. Comparison of antecedent and consequent control approaches to occupational safety. Manuscript submitted for publication, 1980.

2. Komaki, J., Collins, R.L., & Temlock, S. A behavioral assessment of the service sector: Facilitating customer service in a retail merchandising firm. Manuscript submitted for publication, 1980.

References

Andrasik, F. Organizational behavior modification in business settings: A methodological and content review. Journal of Organizational Behavior Management, 1979, 2 85-102.

Babb, H.W., & Kopp, D.G. Applications of behavior modification in organizations: A review and critique. Academy of Management Review, 1978, 3, 281-292.

Biersner, R.J. Attitudes and other factors relating to aviation maintenance training effectiveness (CNETS-6-75). Pensacola, Fla.: Chief of Naval Education and Training Support, December 1975. (NTIS No. AD-A022 4 83/2 SL)

Carpenter-Huffman, P., & Rostker, B. The relevance of training for the maintenance of advanced avionics (RAND/R-1894-AF). Santa Monica, Calif.: Rand Corporation, December 1976. (NTIS No. AD-A047-707/5GA)

Corder, A.S. Maintenance management techniques. London: McGraw-Hill, 1976.

Drake, K.L., Goto, R.N., & Crooks, W.H. Comparative studies of organizational factors in military maintenance (PTR-1043-79-6). Woodland Hills, Calif.: Perceptronics, June 1979. (NTIS No. AD-A071-608/4GA)

Foley, J.P., Jr. Task analysis for job performance aids and related training. In T.C. Rowan (Ed.), Proceedings of invitational conference on improved information aids for technicians (LMI-75-10). Washington, D.C.: Logistics Management Institute, May 1975. (NTIS No. AD-A018-794)

Hannon, W.W. Work authorization and control. In L. Higgins & L. Morrow (Eds.), Maintenance engineering handbook. New York: McGraw-Hill, 1977.

Higgins, L.R., & Morrow, L.C. Maintenance engineering handbook. New York: McGraw Hill, 1977.

Hora, M.E. Five steps to follow in developing a maintenance training program. Plant Engineering, March 30, 1978, pp. 275-278.

Johnson, R.M., & Storr, A. Maintenance trades and supervisory training. In L. Higgins & L. Morrow (Eds.), Maintenance engineering handbook. New York: McGraw-Hill, 1977.

Knight, C.E. The economics of maintenance management. In L.R. Higgins & L. C. Morrow (Eds.), Maintenance engineering handbook. New York: McGraw-Hill, 1977.

Komaki, J., Barwick, K.D., & Scott, L.R. A behavioral approach to occupational safety: Pinpointing and reinforcing safe performance in a food manufacturing plant. Journal of Applied Psychology, 1978, 63, 434-445.

Komaki, J., Collins, R.L., & Thoene, T.J.F. Behavioral measurement in business, industry, and government. Behavioral Assessment, 1980, 2, 103-123.

Komaki, J., Heinzmann, A.T., & Lawson, L. Effect of training and feedback: Component analysis of a behavioral safety program. Journal of Applied Psychology, 1980, 3, 261-270.

McCarty, D.S., & Moore, R.L. Aircraft maintenance cost elements (AFIT-LSSR-17-77B). Wright-Patterson Air Force Base, Ohio: Air Force Institute of Technology, School of Systems and Logistics, September 1977. (NTIS No. AD-A047 640/8GA).

Murphy, R. Work scheduling and controls. In L. Higgins & L. Morrow (Eds.), Maintenance engineering handbook. New York: McGrw-Hill, 1977.

Post, T.J. Comprehensibility of technical manuals. In T.C. Rowan (Ed.), Proceedings of invitational conference on improved information aids for technicians (LMI-75-10). Washington, D.C.: Logistics Management Institute, May 1975. (NTIS No. AD-A018-794).

Prue, D.M., Frederiksen, L.W., & Bacon, A. Organizational behavior management: An annotated bibliograhy. Journal of Organizational Behavior Management, 1978, 1, 216-257.

Schwartz, M.A. Facilities maintenance demonstration study (NPRDC-TR-76-29). San Diego: Navy Personnel and Research and Development Center, January 1976. (NTIS No. AD8009-681)

Shriver, E.L. Fully proceduralized job performance aids: Guidance for performing behavioral analyses (AFHRL-TR-75-38). Falls Church, Va.: URS/Matrix Research Company, June 1975.

Smith, J.P. Briefing on performance and proficiency testing of organizational track vehicle mechanics and maintenance sergeants. Alexandria, Va.: Human Resources Research Organization, October 1961. (NTIS No. AD-A020 0 09/7 SL)

Up, up and away. Time, July 23, 1979, p. 36.

Wilkinson, J.J. How to manage maintenance. Harvard Business Review, March-April 1968, pp. 100-111.